Swift Creek Reservoir
Water Quality Data Report 2012

Chesterfield County
Department of Environmental Engineering
Water Quality Section
&
Department of Utilities
Addison-Evans Water Production/Laboratory Facility

June 2013

Table of Contents

List of Figures and Tables

Executive Summary

This report presents the water quality data collected by the Addison-Evans Water Production and Laboratory Staff for the period of January through December 2012 and represents the twentieth consecutive year of monitoring of the Swift Creek Reservoir. During 2012, pool elevations measured at the dam ranged from 174.1 to 177.3 feet above mean sea level which corresponded to approximate reservoir volumes of <3.5 to 4.7 billion gallons respectively. Sampling occurred once per month at eight stations on the reservoir. Rainfall over the reservoir and its watershed totaled 24.39 inches during 2012, 18.83 inches below the long-term average. During 2012, approximately 800 pounds of copper sulfate were applied to the mainbody and intake bay during May 1 and May 2, 2012. The applications of copper sulfate were performed to improve source water quality for the optimization of the water treatment process.

A higher concentration of chlorophyll *a* was observed in 2012, as compared to 2011, indicating an increased presence of algae in the reservoir. The growing season 90th percentile concentration for the mainstem reservoir stations (Stations 4, 5, 6 and 8) was 20.2 µg/L; slightly greater than the 17.6 µg/L value observed in 2011. No individual chlorophyll *a* concentration measurement or growing season 90th percentile value exceeded the state water quality criterion of 35µg/L, indicating acceptable levels of algal growth in the reservoir.

Throughout the reservoir, a general decrease in total phosphorus concentration was observed. The growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.029 mg/L as P; well below the Virginia Department of Environmental Quality (VADEQ) nutrient threshold of 0.04 mg/L as P. The annual median phosphorus concentration for all eight sites in Swift Creek Reservoir was 0.033 mg/L as P, below the county goal of 0.05 mg/L as P.

During 2012, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper areas beginning in late March and lasting through mid-September. During the stratification period, dissolved oxygen concentrations within the epilimnion were well above the VADEQ criterion of 4.0 mg/L for all stations.

Median growing season Secchi disk readings ranged from 1.0 to 3.2 feet, similar to values noted in prior reports. There was a decrease in the growing season median throughout the reservoir for turbidity (4.5 NTUs) during 2012 indicating an increase in overall water clarity. The continued similarity of both of these parameter's values suggest little if any change in the clarity of the water

within Swift Creek Reservoir. The growing season median total suspended solids concentration for all stations (4.4 mg/L) was identical to that observed in 2011. As in the previous years, total nitrogen levels remained consistent throughout the reservoir. The growing season total nitrogen concentrations were less than observed in past years with site medians ranging from 0.60 to 0.84 mg/L as N and indicated a decrease in nitrogen enrichment. *E. coli* densities remained acceptable with no values greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season.

Water temperature in Swift Creek Reservoir varied normally according to season during 2012. Surface pH values ranged from 6.0 to 7.5 units with an annual in-lake median of 6.7 units. Conductivity measurements within the reservoir ranged from 58 to 125 µS/cm with an annual median of 66 µS/cm. All quarterly measurements of lead and zinc in the surface waters of the reservoir remained acceptable.

A total of 55 individual genera of algae representing six phyla were documented during 2012. Analysis of the general types of algae by phyla in the reservoir indicated that the community structure in 2012 continued to be comprised largely of green algae (Chlorophyta) and golden algae/diatoms (Chrysophyta). While common, the frequency of occurrence for the taste and odor producing blue-green algae (Cyanoprokaryota) decreased compared to 2010 and 2011. There were no widespread taste and odor related problems resulting from algae reported in 2012

The reduction in the density and distribution of *Hydrilla* within the Swift Creek Reservoir following the introduction of the grass carp has been rapid and successful. Since the August 2011 survey, no extant areas of *Hydrilla* have been observed in the reservoir. While the more vegetative structures of the plant have been virtually eliminated, it is anticipated that the plant's presence has not been completely removed. Constant and consistent evaluation of the situation is warranted and eventual replacement of the existing, aging grass carp population is anticipated.

Introduction

This report presents the water quality data collected by the Addison-Evans Water Production and Laboratory staff between January and December 2012 and is the twentieth consecutive year of monitoring of the Swift Creek Reservoir. The Swift Creek Reservoir is a public water supply for Chesterfield County located approximately 20 miles southeast of Richmond, Virginia. The reservoir is a 1700-acre impoundment containing approximately 5.2 billion gallons of water at full pool elevation (178.2 feet above mean sea level). The Swift Creek Reservoir watershed is located in the northwest part of the county and encompasses 61.9 square miles. Although residential development is common in the reservoir's drainage area (31.8% for all residential categories), the most recent land use data (Table 1) indicates the majority (56.8%) of the watershed is comprised of vacant properties.

During 2012, pool elevations measured at the dam ranged from 174.1 to 177.3 feet above mean sea level, corresponding to approximate reservoir volumes of <3.5 to 4.7 billion gallons. Reservoir sampling occurred once a month at eight stations with additional samples obtained every other week at the lacustrine zone Stations 5 and 8 (Figure 1). At these deeper water sites, discrete epilimnion, metalimnion, and hypolimnion samples were taken for nutrient analysis. All other stations in the reservoir (sites 1, 2, 3, 4, 6 and 7) were sampled at the surface only.

Table 1. Land Use Characteristics of the Swift Creek Reservoir Watershed within Chesterfield County. Data obtained from the Chesterfield County Planning Department Development Potential Database 2012 (DPD 12). Categories are arranged in descending order of prevalence.

Land Use Type	Area (acres)	Area (miles^2)	Percent of Watershed
Vacant (no significant structural improvements)	18,697	29.2	56.8
Residential - Single Family	6,322	9.9	19.2
Residential - Single Family (Subdivisions)	3,768	5.9	11.5
Water	1,591	2.5	4.8
Public/Semi-Public	1,403	2.2	4.3
Commercial	371	0.6	1.1
Residential – Multi-family	250	0.4	0.8
Utility	235	0.4	0.7
Office	98	0.2	0.3
Residential – Condominium	76	0.1	0.2
Residential – Townhouse	47	0.1	0.1
Industrial	38	0.1	0.1
Total	32,896	51.4	100.0

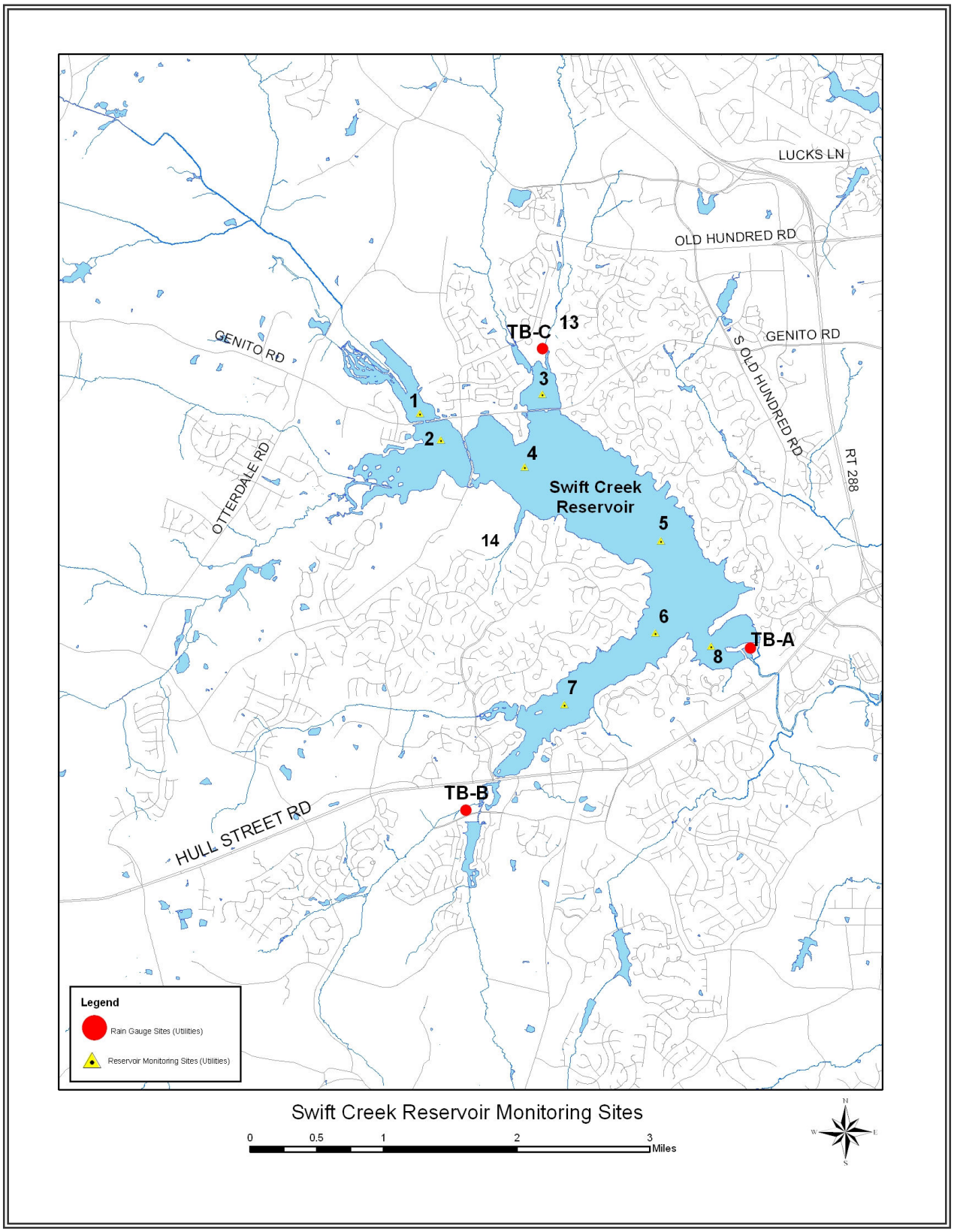

Figure 1. Map of Swift Creek Reservoir monitoring stations.

Water quality parameters (Table 2) were chosen to provide information on basic water quality and the ecological health of the reservoir. Details concerning specific analytical procedures are listed in Table 3.

Rainfall was measured at three automated tipping bucket rain gages within the watershed. The average rainfall over the watershed totaled 24.39 inches during 2012 (Figure 2). Rainfall was 18.83 inches below the long-term average observed over the last 27 years (43.13 inches) and was the least recorded annual rainfall to date.

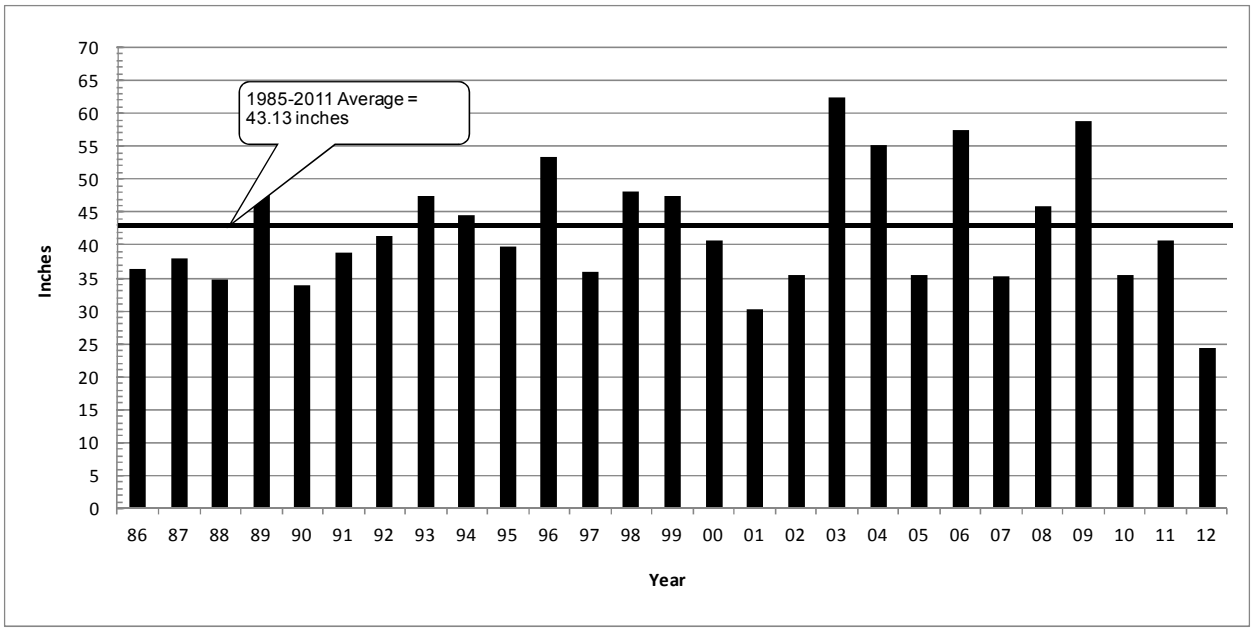

Figure 2. Total Annual Estimated Rainfall Recorded for Swift Creek Reservoir Watershed from 1985-2012 (Source data: Department of Utilities).

Quality Assurance and Quality Control

All analytical methods used were EPA approved, in accordance with *Standard Methods for the Examination of Water and Wastewater* with the exception of the free ammonia analysis, which was conducted following the Hach Chemical Company's test kit procedure. Manufacturers' recommended preventive maintenance procedures were followed for all instruments. For each parameter analyzed, Method Detection Limits (MDLs) were calculated following the EPA procedure as detailed in the *Code of Federal Regulations (CFR), Volume 46, Part 136 Appendix B (EPA, 1984).* Stock and standard solutions were prepared from American Chemical Society reagent grade materials for preparation of calibration standards. Correlation coefficients were evaluated for each calibration curve and had to be greater than or equal to 0.995 to be used for analysis. To ensure calibration validity throughout an analysis, Continuing Calibration Verifications (CCV) standards

were tested after every 10 samples analyzed. Similarly, Continuing Calibration Blanks (CCB) were evaluated after every 10 samples to detect any baseline drift errors. With each analysis, field blanks and digestion/analytical blanks were evaluated to ensure detection of contamination during sampling or sample preparation. Independent source Standard Reference Materials (SRM) were purchased and used to verify the accuracy of each analysis calibration. When any standard (or SRM) was not within 10 percent (per EPA guidelines) of the true value, or CCB showed baseline drift, corrective actions were implemented and samples reanalyzed. An annual ERA performance evaluation of blind nutrient samples in a split sampling study was conducted and reported concentrations for orthophosphate and total phosphorus, ammonia, oxidized nitrogen, and total Kjeldahl nitrogen continued to be within the limits of the ERA's acceptable analytical values.

Table 2. Sampling Regime for Swift Creek Reservoir 2012.

PARAMETERS	RESERVOIR STATIONS 1,2,3,4,5,6,7,8	RESERVOIR STATIONS 5,8
DEPTH	X1	X1
SECCHI DISC	X	X
WATER TEMPERATURE	X1	X1
DISSOLVED OXYGEN (Given as mg/L & % saturation)	X1	X1
CONDUCTIVITY	X1	X1
pH	X1	X1
OXIDATION REDUCTION POTENTIAL	X1	X1
TOTAL PHOSPHORUS	X2	X3
ORTHO PHOSPHATE PHOSPHORUS	X2	X3
TOTAL KJELDAHL NITROGEN	X2	X3
OXIDIZED NITROGEN	X2	X3
AMMONIA NITROGEN	X2	X4
TOTAL ORGANIC CARBON	X2, 1/QTR	X2, 1/QTR
LEAD	X2, 1/QTR	X2, 1/QTR
ZINC	X2, 1/QTR	X2, 1/QTR
SUSPENDED SOLIDS/TURBIDITY	X2	X2
CHLOROPHYLL *a*	X5	X5
PHEOPHYTIN *a*	X5	X5
ALGAE COUNTS	X5	X5
FECAL COLIFORMS (*E. coli*)	X2	X2

X1 - ONE METER INTERVALS

X2 - SURFACE SAMPLING ONLY

X3 - DISCRETE SAMPLES OF EPILIMNION, METALIMNION AND HYPOLIMNION WHEN STRATIFICATION EXISTS ***OR*** SURFACE, MID-DEPTH AND NEAR BOTTOM WHEN NO STRATIFICATION IS PRESENT

X4 - DISCRETE SURFACE AND NEAR BOTTOM SAMPLES

X5 - A COMPOSITE OF BENEATH SURFACE , 1/2/ SECCHI DEPTH, SECCHI DEPTH AND 1-1/2 SECCHI DEPTH SAMPLES

Table 3. Parameters and Analytical Methods 2012.

Parameter	Analytical Method	Detection Limit[1]
Depth	Probe: Hydrolab MiniSonde	± 0.08 m*
Dissolved Oxygen	Probe: Hydrolab MiniSonde	± 0.2 mg/L*
Oxidation Reduction Potential	Probe: Hydrolab MiniSonde	± 20mV*
Water Temperature	Probe: Hydrolab MiniSonde	± 0.1 ^{o}C*
Conductivity	Probe: Hydrolab MiniSonde	± 0.001 µmhos/cm*
pH	Probe: Hydrolab MiniSonde	± 0.2 units
Stage	USGS Staff Gauge	± 0.01 ft*
Flow	Flowmeter: ISCO, Bubble-line	± 0.001m^3/s*
Secchi Depth	20 cm Standard Secchi Disk	± 0.1 ft*
Total Phosphorus	Skalar:EPA Approved, Autom.	0.005 mg/L as P
Orthophosphate	Skalar:EPA Approved, Autom.	0.005 mg/L as P
Total Kjeldahl Nitrogen	Skalar:EPA Approved, Autom.	0.05 mg/L as N
Oxidized Nitrogen	Skalar:EPA Approved, Autom.	0.01 mg/L as N
Ammonia-N	Hach, Salicylate Method 2460	0.03 mg/L as N
Total Organic Carbon	Standard Methods, 5310C	0.5 mg/L
Lead	EPA 200.9, Platform Furnace	2.5 µg/L
Zinc	EPA 289.1, Flame	50 µg/L
Total Suspended Solids	Standard Methods, 2540D	1.0 mg/L
Chlorophyll *a*	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Pheophytin *a*	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Algae Counts	Standard Methods, 10200F	1 cell/mL
Fecal Coliform (*E.coli*) Density	Standard Methods, 9222B (Quanti-Tray)	1.0 MPN/100mL

NOTE: Standard Methods for the Examination of Water and Wastewater, 19th Edition.

* When Reporting Limit based upon detection is not an applicable measurement for a parameter, it has been replaced by an estimation of accuracy (e.g. pH measurement has an estimated accuracy of 0.2 units).

Results and Discussion

Eight stations in the reservoir were sampled monthly during 2012. As in past years, Stations 5 and 8 were sampled twice per month throughout the year to obtain additional data for these deepwater areas. Sampling at all stations included surface water quality grab samples and water column profiles of physical parameters. Supplemental bottom water quality samples were obtained at the mainbody Stations 5 and 8. Specific reports concerning reservoir data are available upon request from the Departments of Environmental Engineering or Utilities.

The county's water quality goal for the annual median concentration of total phosphorus in surface waters is 0.05 mg/L as P or less and was originally based on a Nutrient Controls Standards

Workshop held in 1987 by the Virginia Department of Environmental Quality (VADEQ). In June 2006, Virginia Department of Environmental Quality (VADEQ) adopted freshwater nutrient standards for 116 lakes and reservoirs in Virginia, including the Swift Creek Reservoir. The regulations were approved by the USEPA in July 2007, and the amended water quality standards [9 VAC 25 - 260] became effective August 14, 2007. These regulations set growing season (April through October) chlorophyll *a* and total phosphorus criteria for Swift Creek Reservoir at 35 µg/L (0.035 mg/L) and 40 µg/L (0.040 mg/L as P) respectively. These growing season measurements are by definition intended not to be exceeded for 2 consecutive years as measured by the State in their Lake Monitoring Program. Specifically, VADEQ considers the reservoir nutrient enriched if the 90th percentile of the chlorophyll *a* data in surface waters of the main body of the reservoir (Stations 4, 5, 6, and 8) during the growing season exceeds the criteria for two consecutive years. If algaecides are being used, thus making the chlorophyll *a* measurements unreliable, then both chlorophyll a and total phosphorus criteria are applicable. Additionally, VADEQ considers the reservoir nutrient enriched if the growing season median concentration of total phosphorus in surface waters of the main body of the reservoir exceeds the criterion for two consecutive years.

In the Swift Creek Reservoir, the algaecide copper sulfate is used occasionally to spot treat algal blooms, therefore chlorophyll *a* measurements could be affected. Algaecide use is variable over the reservoir between months and between years. Because of the algaecide treatments, analysis of the reservoir data has always included both the total phosphorus and chlorophyll *a* criteria.

During 2012, approximately 800 pounds of copper sulfate were applied over two days in May to treat algae growth in the reservoir. A total of 400 pounds were applied in the bay adjacent to the water intake tower (in the vicinity of Station 8) and an additional 400 pounds were used in the mainbody of the reservoir. The two 400 pound applications were made on May 1 and May 2, 2012. All applications of copper sulfate were performed to improve source water quality for the optimization of the water treatment process within the plant. Algal blooms are known causes of taste and odor issues in drinking water and can clog filters decreasing available potable water production and supply.

Chlorophyll *a*

VADEQ has identified chlorophyll *a* as the most important parameter that can be measured to determine the nutrient enrichment status of a reservoir. Chlorophyll *a*, a green photosynthetic pigment found in algae, is an indirect measure of biological response to nutrient loadings. VADEQ considers the threshold value for nutrient enrichment in Swift Creek Reservoir to be the 90th

percentile concentration that exceeds 35 µg/L, measured between April and October (*i.e.* the growing season) within the main body for two consecutive years.

An overall higher concentration of chlorophyll *a* was observed in 2012 as compared to previous years indicating a slightly increased presence of algae in the reservoir. The growing season 90th percentile concentration for the mainstem reservoir stations (Stations 4, 5, 6 and 8) was 20.2 µg/L (Table 4), slightly greater than the 18.8 µg/L value observed in 2011. This 90th percentile concentration was the largest observed in the mainstem stations combined since 2009. In 2012, all eight of the stations combined had a 90th percentile concentration during the growing season of 19.9 µg/L, a slight increase from the 18.8 µg/L observed in 2011 but less than the 24.7 µg/L value noted in 2010. The greatest individual measurement observed occurred within the intake bay (Station 8) on June 25, 2011 (31.5 µg/L) and the highest growing season 90th percentile concentration (21.4 µg/L) was observed at Station 5. As in past years, there were no individual measurements or growing season 90th percentile values that exceeded the 35µg/L criteria, indicating acceptable levels of algal growth in the reservoir.

Table 4. Growing Season Chlorophyll a Concentrations (µg/L) 2012.

Station	Growing Season 90th Percentile Chlorophyll *a* (µg/L)
1	14.7
2	18.7
3	17.6
4	15.4
5	21.4
6	15.7
7	17.3
8	20.3
Mainbody Stations (4, 5, 6, 8)	**20.2**
Shallow Stations (1, 2, 3, 7)	**18.6**
All Stations	**19.8**

Total Phosphorus

Total phosphorus is often measured as an indicator of nutrient enrichment. The county has a long established goal of not exceeding an annual median in-lake phosphorus concentration of 0.05 mg/L

as P in order to maintain water quality. The VADEQ has adopted a freshwater nutrient criterion of 40 µg/L (0.040 mg/L as P) for the surface waters of the reservoir's main body for the growing season. The growing season (April – October) median total phosphorus concentrations for each reservoir station are provided in Table 5.

Table 5. Growing Season Median Total Phosphorus Concentrations (Surface) for 2012.

Station	Growing Season Median Total Phosphorus (mg/L as P)
1	0.073
2	0.045
3	0.032
4	0.035
5	0.027
6	0.029
7	0.028
8	0.028
Mainbody Stations (4, 5, 6, 8)	**0.029**
Shallow Stations (1, 2, 3, 7)	**0.038**
All Stations	**0.033**

In 2012, the growing season median total phosphorus concentration in the reservoir for all sites combined was 0.033 mg/L as P, an observation below the county goal of 0.05 mg/L as P. A general decrease in total phosphorus concentration was noted as compared to the 2011 value with concentrations similar to those observed in 2010. The growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.029 mg/L as P, an improvement from the 0.041 mg/L as P concentration noted in 2011. The 2012 growing season median value observed in the mainbody represented a value below the VADEQ freshwater nutrient criterion of 0.04 mg/L as P (Figure 3). With the exception of Stations 1 and 2, all individual station growing season medians were below the 0.04 mg/L threshold. At these stations the growing season medians were greater than 0.04 mg/L as P indicating nutrient enrichment (Table 5). It should be noted that the state phosphorus criterion is only applicable for the lacustrine zone (Stations 4, 5, 6 and 8) and is not intended as a regulatory value for the shallow, backwater areas of the reservoir. During the 2012 growing season, for all sites monitored in the reservoir, 28 individual measurements (25.0%) were at or exceeded 0.04 mg/L as P, approximately half that observed in 2011 (n=40; 58.0%). The annual median phosphorus concentration for all eight sites in Swift Creek

Reservoir was 0.033 mg/L as P. The total phosphorus levels present in Swift Creek Reservoir indicate that in 2012 this water body exhibited a general decrease in nutrient enrichment.

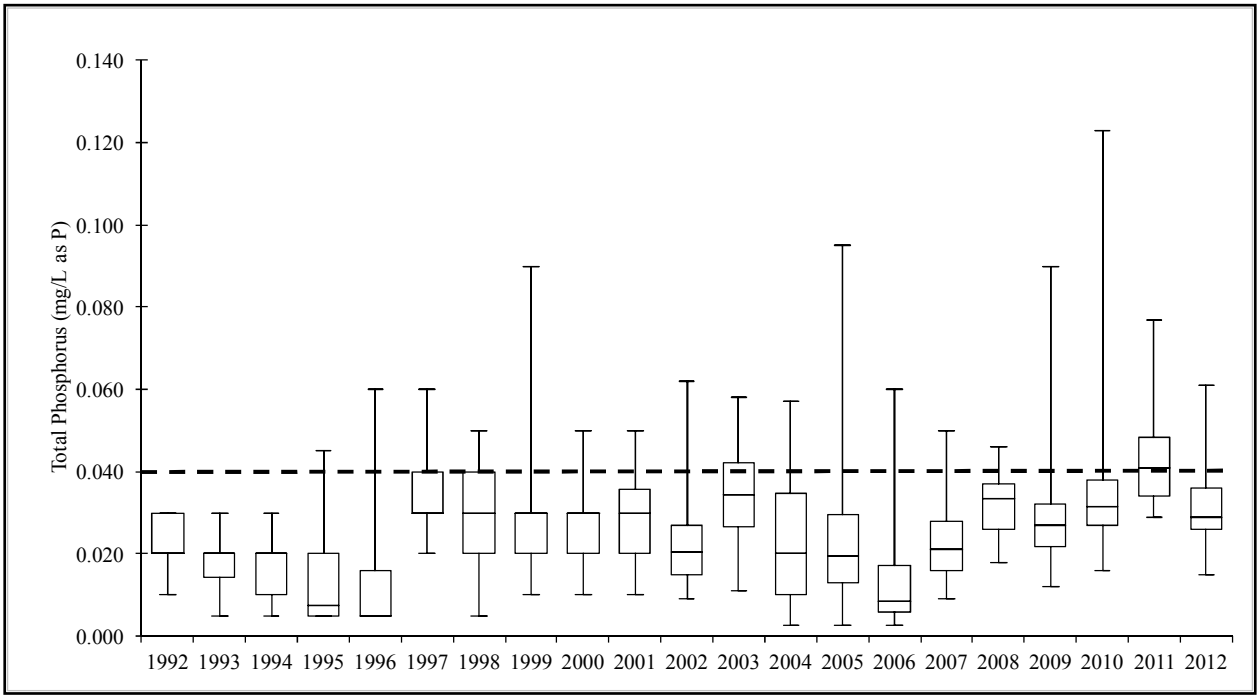

Figure 3. Box plot demonstrating the growing season median total phosphorus concentrations and ranges of observations for the surface waters of main body sites within Swift Creek Reservoir 1992 - 2012. Dashed line denotes VADEQ maximum threshold of 0.04 mg/L as P for acceptable water quality.

Higher concentrations of total phosphorus in anoxic (oxygen depleted) bottom waters compared to surface water concentrations indicate active phosphorus release from sediments. The release of phosphorus from the sediments results in additional nutrient loading to the reservoir, as this phosphorus is then mixed with the upper water layers during de-stratification. At Stations 5 and 8 during 2012, there were 33 instances where the concentrations of total phosphorus in the benthic sample were greater than the values obtained at the surface. Of these 33 instances, nine were considered substantial (*i.e.* ≥50% difference) with eight occurring during a period of true anoxia (dissolved oxygen concentration ≤ 1.0 mg/L) near the benthic sediment. These observations were made during the approximate period from June to September at Stations 5 and 8 with bottom phosphorus concentrations ranging from 0.033 to 0.152 mg/L as P. This represented a median bottom concentration of 0.055 mg/L and a differential of 68% increase as compared to the median surface concentration (0.028 mg/L as P). The remaining differences noted were either minor (≤50% difference) or were observed when true anoxia in the benthos was not present. While total

phosphorus contributions from the sediment were not significant, the higher concentrations in the anoxic hypolimnion continue to contribute to loading. Incrementally over time the reservoir sediments increase the loading to the overall water column phosphorus budget.

Dissolved Oxygen

Adequate dissolved oxygen is critical in the promotion of a healthy aquatic environment and as good quality source water for municipal treatment facilities. Hypoxic conditions occur when dissolved oxygen drops below 5.0 mg/L, resulting in stress on fish and other aquatic life. An anoxic condition occurs below 1.0 mg/L, which can result in fish kills and the release of phosphorus, iron, manganese, and other elements from the sediments. The release of these elements can result in increased algal blooms and treatment problems (undesirable tastes and odors) for the production of drinking water.

In July 2007, EPA approved the VADEQ's proposed dissolved oxygen standard (5.0 mg/L daily average, 4.0 mg/L minimum), which had been modified to account for naturally occurring decreases in dissolved oxygen due to thermal stratification in reservoirs. These new standards apply to the entire water column when the reservoir is well mixed and only to the surface waters (epilimnion) when the water column is vertically stratified. From 2002 to 2006, Swift Creek Reservoir was listed on the VADEQ's 303(d) listing of impaired water bodies for not meeting the dissolved oxygen standard due to naturally occurring conditions. The most recent VADEQ's 303(d) listing of impaired water bodies does not include the Swift Creek Reservoir.

Thermal stratification is a natural process in many lakes and reservoirs that occurs when summer conditions warm the upper water column while the lower water column remains cooler. The warmer surface waters become lighter than the colder and denser bottom waters, resulting in two layers of water separated by a zone of sharply changing temperature ("thermocline") that inhibits vertical mixing. The thermal stratification typically continues until falling temperatures in the autumn cool the surface water sufficiently to break up the thermocline. Often a large fall storm event will result in a rapid de-stratification of the lake.

During 2012, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in late March and lasting through mid-September. Thermal stratification of Swift Creek Reservoir was first observed on March 29, 2012 at Station 5, corresponding with the first substantial drop in dissolved oxygen levels at and near the bottom. Stratification continued at Station 8 until September 24, 2012, when the lake turned over and became thoroughly mixed. During the stratification period, dissolved oxygen concentrations within the epilimnion were well

above the VADEQ standard of 4.0 mg/L minimum for all stations. These time periods and degree of thermal and dissolved oxygen stratification with Swift Creek Reservoir were consistent with past observations.

Secchi Depth, Total Suspended Solids, Turbidity, Total Nitrogen and Fecal Coliforms

Secchi depth is a measurement of water transparency using a weighted black and white disk that is lowered into the water until it is no longer visible. The depth at which the disk is no longer visible is then recorded as "Secchi disk transparency". Secchi disk transparency is basically a function of the reflection of light from the surface of the disk. Secchi disk transparency is affected by the light absorption characteristics of the water as well as by dissolved and suspended particulate matter. It provides an estimate of water clarity and is closely related to turbidity.

Table 6. Growing Season Median Values for Select Parameters (Surface) 2012.

STATION	SECCHI DEPTH (Feet)	TURBIDITY (NTUs)	TOTAL SUSPENDED SOLIDS (mg/L)	TOTAL NITROGEN (mg/L as N)	Fecal Coliform (*E. coli*) (MPN/100 mL)
1	1.0	16.0	20.2	0.65	14.8
2	2.0	10.3	8.0	0.84	6.9
3	2.0	7.8	6.8	0.80	14.1
4	2.6	3.9	4.4	0.61	3.6
5	2.9	4.4	4.4	0.60	3.1
6	3.0	3.6	4.4	0.60	5.8
7	2.6	3.6	4.4	0.61	4.7
8	3.2	3.6	3.8	0.69	5.2
Mainbody Stations (4, 5, 6, 8)	**2.9**	**3.9**	**4.4**	**0.61**	**4.1**
Shallow Stations (1,2,3 & 7)	**2.0**	**7.4**	**7.2**	**0.76**	**8.0**
All Stations	**2.6**	**4.5**	**4.4**	**0.66**	**5.2**

All stations had median growing season Secchi disk readings ranging from 1.0 to 3.2 feet (Table 6), similar to those noted in prior reports. The 2012 growing season median value for all sites (2.6 feet) was slightly lower than the medians observed the previous two years (3.0 feet). Individual site growing season medians for turbidity ranged from 3.6 to 16.0 NTUs with the greatest measurements observed in the shallow backwater stations. The growing season turbidity median (4.5 NTUs) was almost half that observed in 2011 (8.2 NTUs). The long-term consistency of both the Secchi disk

depth and turbidity parameter measurements suggests minimal variability in water clarity.

The 2012 growing season median total suspended solids concentration for all stations (4.4 mg/L) was identical to the 2011 observation. As in the previous years, total nitrogen levels remained fairly consistent throughout the reservoir with growing season median concentrations ranging from 0.60 to 0.84 mg/L as N (Table 6). The 2012 growing season median for all stations (0.66 mg/L as N) was slightly less than that observed in 2011 (0.83 mg/L as N) and indicated a general decrease in nitrogen enrichment throughout the reservoir. The mainbody stations median growing season medians were typically less than those noted in the shallow backwater areas.

Fecal coliform densities as expressed as the Most Probable Number (MPN) of *E. coli* per 100mL ranged from a growing season median of 3.1 MPN/100mL at Station 5 to 14.8 MPN/100mL at Station 1 during 2012. The growing season median for all stations in 2012 was recorded at 5.2 MPN/100mL. There were no individual values were greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season during 2012. From January to December 2012 there were 10 instances in the reservoir where *E. coli* densities were greater than the VADEQ maximum threshold (9.6% of total observations). In these occurrences, coliform densities ranged from 275.5 to 1119.9 *E. coli* MPN/100mL. Seven of these occurrences were noted at Stations 4 and 5, areas of the mainbody of the reservoir frequently populated by migratory and resident waterfowl. As mentioned in previous reports, the isolated measurements of high *E. coli* densities could be related to these birds congregating on the open waters during cold weather months.

Temperature, pH, Conductivity, Lead and Zinc

Water temperature in Swift Creek Reservoir varied normally according to season during 2012. Surface temperatures throughout the reservoir ranged from 4.1 to 29.7^{o}C during the year with a median value of 18.1^{o}C, slightly cooler than the median observed in the past two years. No individual surface temperatures exceeded the VADEQ maximum standard of 32.0^{o}C during 2012. Surface pH values ranged from 6.0 to 7.5 units with an annual in-lake median of 6.7 units, consistent with the 6.6 unit value observed in 2011. No individual surface values fell outside of the 6.0 to 9.0 unit VADEQ acceptable range for pH during 2012. Conductivity measurements within the reservoir ranged from 58 to 125 µS/cm with an annual median of 66 µS/cm; an observation consistent with previously recorded values. All quarterly measurements of lead and zinc in the surface waters of Swift Creek Reservoir remained acceptable during 2012. Lead concentrations were typically below the reporting limit (<0.0025 mg/L) with only four measurable concentrations noted during 2012. These measurements were recorded at Stations 2, 3, 4 and 6 during the July 12, 2012 survey and ranged from 0.0027 to 0.0182 mg/L. Zinc concentrations were likewise typically below the

laboratory's detection limit (0.05 mg/L) with only four measurable concentrations noted during 2012 These measurements were recorded at Station 1 during the January 6, 2012 survey and at Stations 3, 4 and 8 during the July 12, 2012 and ranged from 0.057 to 0.724 mg/L. These measureable levels were transient and concentrations observed in the subsequent sampling indicated no detectable levels of lead and zinc.

Algal Community Structure of Swift Creek Reservoir

A total of 55 individual genera of algae representing six phyla were documented in Swift Creek Reservoir during 2012. While four taxa greater than observed in 2011, this observation was largely consistent with the numbers and types reported during previous years. Analysis of the general types of algae by phyla in Swift Creek Reservoir indicated that the community structure in 2012 continued to be comprised largely (80.4%) of green algae (Chlorophyta) and golden algae/diatoms (Chrysophyta) combined, similar to the composition noted in previous years. While common, the frequency of occurrence for the taste and odor producing blue-green algae (Cyanoprokaryota) decreased compared to 2010 and 2011 (Figure 4).

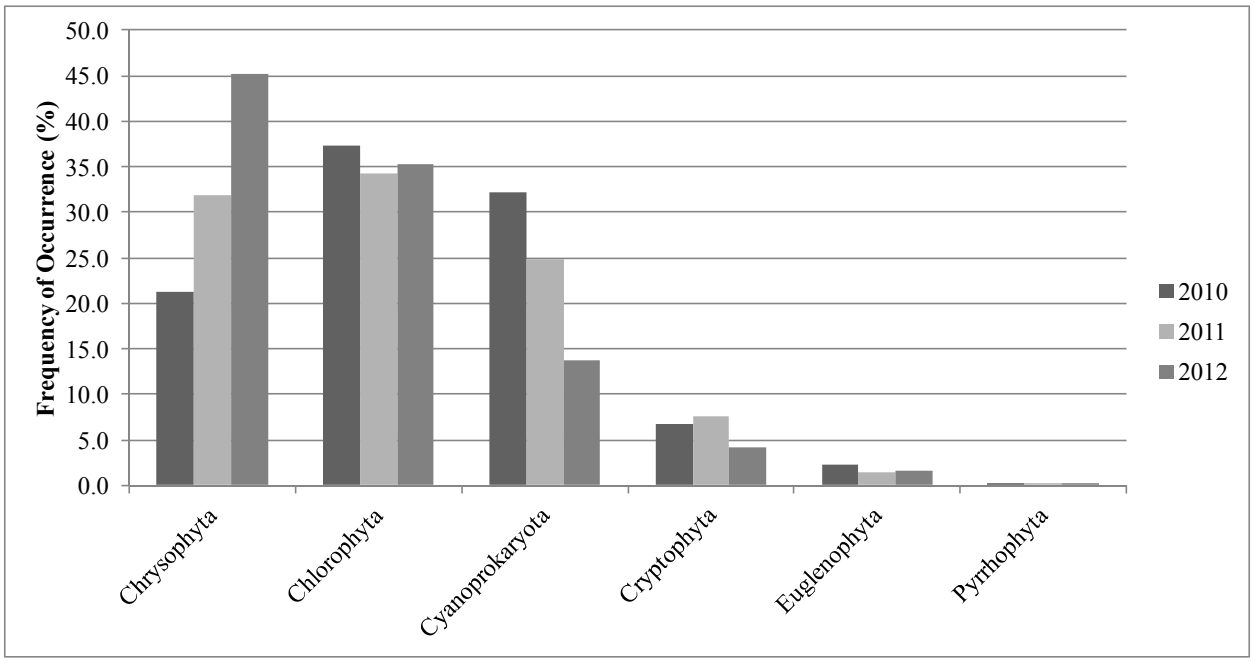

Figure 4. A comparison of the frequency of occurrence of six algae phyla observed in Swift Creek Reservoir 2010 - 2012.

From this total data set, the ten most common taxa were identified (Table 7). These ten taxa combined represented approximately 77% of all algae observed in 2012. There were no widespread

taste and odor related problems resulting from algae reported in 2012.

Table 7. Ten most common taxa of algae observed in Swift Creek Reservoir 2012.

Number	Phyla	Genus	% of Total Observed	Taste/Odor Produced
1	Chrysophyta	*Melosira*	17.7	Musty
2	Chrysophyta	*Chysochromulina*	12.2	Not Known
3	Chlorophyta	*Dictyosphaerium*	9.2	Fishy
4	Chlorophyta	*Ankistrodesmus*	8.0	Grassy/Musty
5	Chrysophyta	*Tabellaria*	7.0	Grassy/ Fishy
6	Chlorophyta	*Crucigenia*	6.9	Not Known
7	Chlorophyta	*Scenedesmus*	5.3	Grassy
8	Cyanoprokaryota	*Anabaena*	4.3	Rotten/Septic
9	Cyanoprokaryota	*Pseudanabaena*	3.6	Earthy
10	Chrysophyta	*Nitzschia*	2.9	Not Known

Status of *Hydrilla* and its Control in the Swift Creek Reservoir

As discussed in the previous Swift Creek Reservoir Water Quality Data Report, the rapid growing invasive aquatic weed, *Hydrilla verticillata*, was first identified in the Swift Creek Reservoir in August 2009. After an intensive study of the problem, including consultation with Dr. Kenneth Wagner (a recognized expert in aquatic weed control), action for the long-term management of *Hydrilla* was initiated by the introduction of 10,500 triploid grass carp (*Ctenopharyngodon idella*) to the reservoir in April 2010. The sterile grass carp were approximately 12 inches in length and weighed 1.0 to 1.5 pounds. An electrofishing survey conducted in September 2011 observed that seventy percent of the fish recovered had grown to 27 - 28 inches in length and weighed 8 - 10 pounds, indicating a healthy and growing population.

The reduction in the density and distribution of *Hydrilla* within the Swift Creek Reservoir following the introduction of the grass carp was rapid and successful. A combination of grazing pressure by the grass carp and natural die-back from cold winter water temperatures resulted in a substantially noticeable reduction to 107 acres of *Hydrilla* growth by June of 2011. By the August 2011 survey, no visible areas of *Hydrilla* were present and this observation was confirmed again in the October survey. Additional surveys conducted during 2012 have confirmed that the grass carp continue to be effective in controlling the growth of *Hydrilla*. While the more vegetative structures of the plant

have been virtually eliminated, it is anticipated that the plant's presence has not been completely removed. In addition to seed deposition, reproductive strategies such as root structures that produce tubers, fragments of leafy growth and turions on stems structures are all mechanisms that *Hydrilla* uses to survive. Continued success in grass carp maintenance of *Hydrilla* is expected in the upcoming year. Constant and consistent evaluation of the situation is warranted and eventual replacement of the existing, aging grass carp population is anticipated.

Conclusions

Indicators of water quality continue to suggest acceptable conditions in the Swift Creek Reservoir. An overall higher concentration of chlorophyll *a* was observed in 2012, as compared to 2011, indicating an increased presence of algae in the reservoir. Throughout the reservoir, a general decrease in total phosphorus concentration was observed. The growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.029 mg/L as P; well below the Virginia Department of Environmental Quality (VADEQ) nutrient threshold of 0.04 mg/L as P. The annual median phosphorus concentration for all eight sites in Swift Creek Reservoir was 0.033 mg/L as P, below the county goal of 0.05 mg/L as P.

As in prior years, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in late March and lasting through mid-September. During this stratification period, dissolved oxygen concentrations within the epilimnion remained above the VADEQ standard of 4.0 mg/L for all stations.

Secchi disk readings ranged from 1.0 to 3.2 feet and while similar to those noted in prior reports, were overall slightly lower than observed the previous two years. Individual site growing season medians for turbidity ranged from 3.6 to 16.0 NTUs with the greatest measurements observed in the shallow backwater stations. The growing season total nitrogen concentrations were less than observed in past years with site medians ranging from 0.60 to 0.84 mg/L as N and indicated a decrease in nitrogen enrichment. There were no observations of individual *E. coli* density values greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season. Water temperature in Swift Creek Reservoir varied normally throughout the year. All surface pH values were within the VADEQ standard range of 6.0 – 9.0 units. All other physical and chemical measurements were acceptable.

A total of 55 individual genera of algae representing six distinct phyla were documented in Swift

Creek Reservoir during 2012 and analysis of the general types of algae indicated that the community structure continued to be dominated by green algae and golden algae/diatoms. There were no indications of algae related taste and odor problems reported in 2012. Vegetation surveys confirmed that the efforts in the reduction of the density of *Hydrilla* within the Swift Creek Reservoir have been rapid and successful. While the more vegetative structures of the plant have been virtually eliminated, it is anticipated that the plant's presence has not been completely removed and constant and consistent evaluation of the situation is warranted with eventual replacement of the existing, aging grass carp population anticipated. Efforts in 2012 will continue to emphasize the monitoring of source water quality, the extent and distribution of *Hydrilla*, and the health and growth of the grass carp.